UNITED STATES DEPARTMENT OF LABOR
Mine Safety and Health Administration

EVALUATION OF THE UNI TRONIC 500™ ELECTRONIC BLASTING SYSTEM REQUIREMENTS FOR SHUNTING AND CIRCUIT TESTING

PAR 0092059
August 2006

By

Tom Lobb and Harry Verakis

-Originating Office-

MSHA TECHNICAL SUPPORT
APPROVAL AND CERTIFICATION CENTER
Industrial Park Road
P. O. Box, Box 251
Triadelphia, West Virginia 26059
(304) 547-0400

TABLE OF CONTENTS

CAPTIONS

Purpose

MSHA has received inquiries about how the MSHA requirements for shunting and circuit testing are appled to electronic detonators. The purpose of this specific report is to discuss the technical findings and the issues of "shunting" and "circuit testing" for the Orica Unitronic 500™ electronic detonator system with regard to the MSHA standards.

With respect to **electric** detonators, the coal and metal-nonmetal mine requirements for shunting and circuit testing are specified in 30 CFR 77.1303 (y)(1),(2),(3) and 77.1303(z); 56.6401(a),(b),(c); 56.6407(a),(b),(c),(d) and 57.6401 (a),(b),(c) and 57.6407 (a) and 57.6407 (b). **Electric** blasting systems are designed differently than electronic detonator systems and the design features are not the same. Each electronic detonator system differs in design, construction, operation and testing features.

To resolve the issue of "shunting and "circuit testing", technical information was needed on the details of the Orica Unitronic 500™ electronic detonator system.

2. **Introduction—Using Electric Detonators**

Electric detonator systems for performing blasting operations have been in use in the mining industry for many decades. They are used in both series and parallel blasting circuits. All electric detonators produced in the USA have shunts on the free ends of the leg wires. The shunt provides a low resistance path to prevent current from flowing through the bridge wire of the electric detonator. In other words, with a shunt both of the leg wires are at the same potential to prevent extraneous current flow into the detonator. In addition, some designs completely enclose the ends of the wires in order to prevent corrosion and to prevent bare wires from contacting extraneous electrical current sources. The shunt is removed when an electric detonator is connected into the blasting circuit. Electric detonators are supplied with a distinctive, numbered tag to facilitate easy identification of the delay period.

Since electric detonators are designed to fire when electrical energy is supplied to them, any extraneous source of electric current represents a potential source for initiation. Sources such as lightning, high voltage power lines, radio transmitters, and static electricity must be avoided. There are also occurrences where the energy from lightning has traveled several miles along pipes or cables into an underground mine and can represent an unsuspected source for initiation of electric detonators.

When using electric detonators, the continuity and resistance of the individual detonator as well as the entire circuit needs to be tested with a blasting galvanometer. A blasting galvanometer is used to check the individual detonators prior to making the primer and again prior to stemming the borehole. Care should be taken when stemming a borehole to prevent any possible damage to the detonator leg wires. Once the circuit is completely wired, it should be checked again. When the blast line is connected to the circuit, the resistance needs to be checked prior to connecting the blasting unit.

When electric detonators are initiated, current leakage from the blasting circuit must also be prevented. If bare wires are allowed to come into contact with another conductor or even a conductive portion of the ground, some of the electric energy may leak out of the circuit causing misfires.

3. **Technical Discussion**

An electric detonator consists of two leg wires embedded in a metal shell which contains a high explosive base charge designed to initiate other explosives. Electric detonators are typically designed with an ignition mixture, a pyrotechnic fuse train (for the delay element) and a base charge, respectively (See Figure 1). A thin metal filament, known as a bridgewire, is attached between each end of the leg wire and is embedded in an ignition mixture. The pyrotechnic delay element is designed to burn at an approximated rate. The length and composition of the pyrotechnic train control the approximate rate of burn and thus the timing of when the detonator fires. Since the approximate rate of burn is subject to variation, the firing time accuracy of the electric detonator is affected. When sufficient electrical current passes through the bridge wire, it becomes hot enough to ignite the ignition mixture. This event initiates the pyrotechnic element in the delay train which then initiates the base charge.

Electronic detonator systems are new technology advancements for the initiation of blasts in mining operations. Their introduction into mine blasting operations is beginning to advance. Several advantages for electronic detonators are precise timing, reduced vibrations, a reduced sensitivity to stray electrical currents and radio frequencies, and a great reduction in misfires through more precise circuit testing.

Electronic detonators have been designed to eliminate the pyrotechnic fuse train that is a component of electric detonators, thus improving timing accuracy and safety. For the electronic detonators, typically an integrated circuit and a capacitor system internal to each detonator separate the leg wires from the base charge. Depending on the design features of the electronic detonator, the safety and timing accuracy can be greatly improved. An example of the constructional features of an electronic detonator is shown in Figure 2. The electronic detonator is obviously a more complex design compared to an electric detonator. A specially designed blast controller unique to each manufactured system transmits a selectable digital signal to each wired electronic detonator. The signal is identified by each electronic detonator and the detonation firing sequence is accurately assigned. The manufacturer's control unit will show any incomplete circuits during hookup prior to initiation of the explosive round. The wired round won't fire until all detonators in the circuit are properly accounted for with respect to the current blasting plan layout.

As part of the resolution of the "shunting" and "circuit testing" issues, a technical evaluation was made of the UNI Tronic 500™ Electronic Blasting System. Where UNI Tronic is used in this report, it is a trademark designation and represents the electronic blasting system mentioned. In addition to evaluation of the technical documents provided by Orica, MSHA personnel observed the performance of the UNI Tronic 500™ blasting system at a surface mining operation.

<u>Orica UNI Tronic™ 500 Electronic Blasting System (Orica USA Inc.)</u>

The basic components of the UNI Tronic 500™ Electronic Blasting System include the electronic detonator with leg wires, the blast box, the "Network tester" (electrical tester), and an infrared bar code reader. The UNI Tronic 500™ electronic blasting system is easily identified by a yellow duplex legwire with a unique barcode ID for each detonator (See Figure 3). Each electronic detonator has an assigned traceable ID number held on the internal chip and printed on a tag which is attached to the leg wire connector. In setting up the round to be blasted, the UNI Tronic 500™ electronic detonator is inserted into the booster (See Figure 4). This primer is then loaded into the borehole. Next, the borehole is loaded with the chosen blasting agent (See Figure 5). Prior to stemming the borehole, the UNI Tronic "Network tester" is plugged in to each detonator, one at a time (See Figure 6). During this step, the UNI Tronic 500™ electronic detonator is systematically checked for short circuits, open circuits, and operational integrity. Once this check has been made, the UNI Tronic 500™ electronic detonator is connected into the blasting circuit. The blasting circuit is checked again with the "Network tester." The order of connecting the electronic detonators or the sequence of connecting them does not affect the timing values. The lead-in wire is then connected to the blast box after the blast area is cleared. The bar code reader is then inserted into the blast box and its information is downloaded. The blaster follows the screen instructions on the blast box as it assigns each detonator its final bottom hole timing delay value (Figure 7). All of this information from the bar code reader is stored in the UNI Tronic blast box while the timing value is permanently stored into the integrated circuitry of the electronic detonator. The blast box also checks for continuity, extra detonators, and for detonators that have faulty connections or no connections at all. This information is displayed on the blast box screen before the blast can be armed and fired. The information is then used to check against the blast plan. The UNI Tronic blast box unit will not arm the round until the system operational check is completed and no errors are indicated. Once the round is armed, the blaster can initiate the blast from the blast box.

4. <u>**Mine Field Trip**</u>

A field trip was made to a surface mining operation to examine and witness the use of the UNI Tronic 500™ electronic blasting system. The system detected open blasting circuits which enabled the blasting crew to specifically locate and correct the fault. This test indicates the systems ability to prevent misfires, thus minimizing a major safety hazard associated with blasting operations.

Surface coal mine visit. A visit was made to a surface coal mine operation in western Virginia to view the Orica UNI Tronic 500™ electronic blasting system in operation. The blast site contained 93 holes. The diameter of each hole was 9 inches and the depth was 50-60 feet. The electronic detonators and boosters were laid out and assembled. The UNI Tronic™ 500 electronic detonator with its unique ID tag is shown in Figure 3. A one pound booster primed with an Orica UNI Tronic 500™ electronic detonator was lowered into each blast hole prior to loading with ANFO-emulsion blend from several bulk loading trucks (See Figure 8). The "Network tester" was connected to the leg wire of each electronic detonator separately (shown in Figure 6). The circuit continuity and integrity were checked. Then each detonator was scanned with the bar code reader and the desired delay was entered into the bar code reader for that scanned detonator. For tracking, each detonator has a separate unique ID number already assigned at the factory.

In preparation for blasting, each primed blast hole is loaded with ANFO from a bulk loading truck and then stemmed (See Figure 9). Once the whole round was scanned using the Orica bar code reader and then tested with the “Network tester”, all the detonators were then connected to the main firing line. The data from the bar code reader is then transferred to the UNI Tronic 500™ Blast Box. The delay time is stored in the internal chip of the electronic detonator and the bar code reader. The UNI Tronic 500™ Blast Box then checks the wired round for short circuits and unconnected firing lines, and missing or extra detonators. This test indicated that one hole, #92 was not registering as being connected. The Orica Blast Box had indicated the particular unconnected detonator and the detonator was located. This is an important feature, since it prevented the occurrence of a misfire. Also the Orica Blast Box served the purpose of a blasting galvanometer by checking the continuity of the system.

Following a complete check of the blasting system, the blast area was cleared and the wired round was armed and fired with the Blast Box as planned. All the blastholes fired and the blast was successful. A photograph of the blast is shown in Figure 10.

This field trip to examine an actual blast showed that the Orica UNI Tronic 500™ electronic blasting system performed as intended. The diagnostic evaluation using the “Network tester” and the preblast diagnostic testing performed with the Orica Blast Box satisfied the MSHA requirement for circuit testing.

5. <u>Conclusions</u>

The shunting issue was evaluated in the technical and field review of the UNI Tronic 500™ electronic blasting system. The means of shunting for the Orica UNI Tronic 500™ electronic detonator is provided by its specific internal design and construction features unlike a shunt for a conventional electric detonator. This electronic blasting system has undergone extensive testing which included sources of stray and extraneous electricity and provides a higher level of safety than conventional electric detonators. The Orica UNI Tronic 500™ electronic blasting system has an internal design for shunting within the electronic detonator and circuit testing with the “Network tester” and the Blast Box that meet the intended MSHA requirements. Therefore, the Orica UNI Tronic 500™ electronic blasting system does not need to be physically shunted and circuit tested by using a blaster’s galvanometer as would be performed for conventional electric detonators. Because of the unique design and construction of this system, it must be used according to the manufacturer’s instructions.

6. Summary

Electronic detonator systems are one of the newer technologies being introduced into the mining industry. Their advantage is thorough pre-blast circuit testing and very precise detonator firing time. An integrated circuit chip and an internal capacitor system control the detonator initiation time. The electronic blasting systems observed have an unparalleled safety feature, since they cannot be initiated by a conventional blasting unit. However, electronic detonators can still be initiated by lightning, fire, and impact of sufficient strength. It is anticipated that a decrease in the number of pre-detonations, misfires, and other unintentional initiations should result from the use of electronic detonator systems.

The design and operational features of the Orica UNI Tronic™ 500 electronic blasting system have been technically reviewed and the field use of the system has been observed at a mine site. The Orica UNI Tronic™ 500 blasting system has its own proprietary electronic design for shunting and circuit testing that meets the intended MSHA requirements.

This report is posted on MSHA's web site and may be accessed under Technical Reports at http://www.msha.gov/TECHSUPP/ACC/ACCHOME.HTM. Also, an MSHA Program Information Bulletin (PIB 04-20) on electronic detonators and requirements regarding shunting and circuit testing is available on MSHA's web site. The bulletin may be accessed at http://www.msha.gov/regs/complian/PIB/2004/pib04-20.htm.

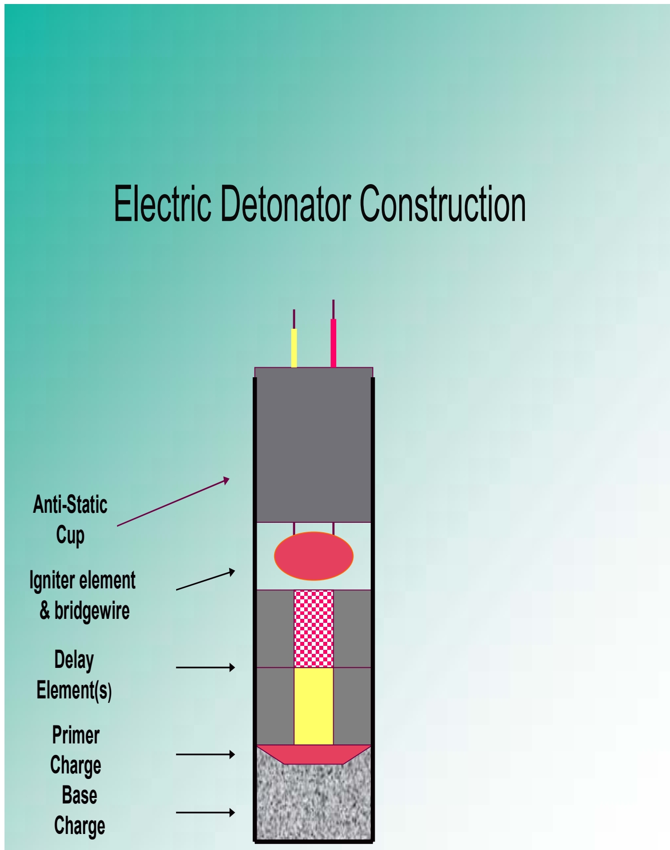

Figure 1 – Electric Detonator Components

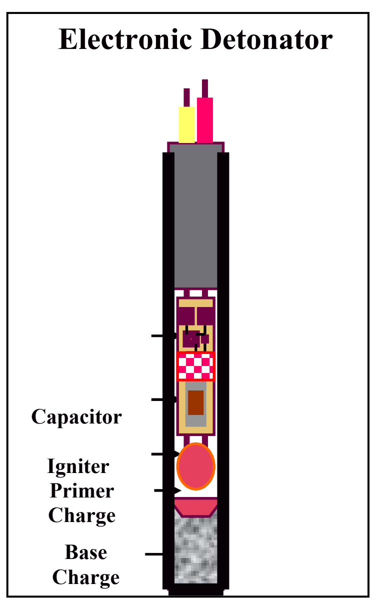

Figure 2 – Electronic Detonator Components

Figure 3 – Orica UNI Tronic 500™ Bar Code reader

Figure 4 – Orica UNI Tronic 500™ detonator plus booster

Figure 5 – Loading a blasthole

Figure 6 -- Orica UNI Tronic 500™ Network Tester

Figure 7 -- Orica UNI Tronic 500™ Blast Box with the
bar code reader inserted to download detonator information

Figure 8 – Priming blasthole with booster prior to loading with ANFO-emulsion blasting agent

Figure 9 – Stemming the blasthole

Figure 10 – Firing of the blast using the Orica UNI Tronic 500™ Blast Box